

**WEEKLY INFORMATION ITEM
M E M O R A N D U M**

TO: Mayor McGrath and City Council

FROM: Jane S. Brautigam, City Manager
Stephanie Grainger, Deputy City Manager
Maureen Rait, Executive Director of Public Works
Robert E. Williams, Director of Public Works for Utilities
Robert Harberg, Utilities Project Engineering Coordinator

DATE: January 29, 2009

SUBJECT: South Boulder Creek Flood Mapping Study Update and Plan for new Floodplain Regulation

EXECUTIVE SUMMARY:

City staff recently sent a re-submittal package for the South Boulder Creek (SBC) Flood Mapping Study results to the Federal Emergency Management Agency (FEMA), dated Dec. 30, 2008 (see **Attachment A**). It is anticipated that FEMA will complete its review of the revised flood study results in early 2009 and will solicit public comment as part of its review process. The SBC mapping study results are intended to replace the current regulatory mapping that is based on a 1986 United States Army Corps of Engineers (USACE) study.

Assuming the study results are accepted by FEMA, there will be 700 structures (with a total of approximately 1,200 dwelling units) in the 100-year floodplain (Zone AE). Currently, there are approximately 460 structures (with approximately 500 total dwelling units) in the 100-year floodplain. Structures affected by the existing regulatory mapping are also affected under the new study results. Therefore, approximately 240 additional structures (with approximately 700 total dwelling units) will be impacted.

FISCAL IMPACT:

Currently, funding has been included in the city's CIP in 2008-2010 to complete the risk assessment and the flood mitigation planning effort, and \$3 million has been proposed in the city's 2011 budget to help fund flood mitigation construction improvements. (Specific improvements are yet to be determined by the flood mitigation planning mentioned above.) Also, an agreement with the Urban Drainage and Flood Control District has been secured and provides a total of \$100,000 of supplemental funding for flood mitigation planning.

The city is pursuing federal funding to help offset the cost of flood mitigation planning and flood mitigation project construction. Congress appropriated \$98,400 in fiscal year 2008 for use by the U.S. Army Corps of Engineers to initiate the General Investigation Study of this floodplain. The city requested an additional \$500,000 in the fiscal year 2009 budget, and U.S. Senator Wayne Allard secured \$250,000 for the project as part of the 2009 Senate Energy and Water Development Appropriations Subcommittee Appropriations Bill. There is no funding mentioned in the President's budget for 2009, so hopefully there will be support in the U.S. House and

Senate conference for this funding. It is important that flood mitigation planning efforts proceed concurrently with the U.S. 36 Corridor Improvements-Environmental Impact Statement.

COMMUNITY SUSTAINABILITY ASSESSMENTS AND IMPACTS:

Economic: Economic impacts will primarily affect existing business and residential property owners in the West Valley. The impacts are primarily due to flood insurance costs that will likely be required by mortgage companies. However, this same flood insurance will also provide protection from catastrophic losses due to potential floods. The flood mapping will require that additional properties will be subject to the city's and county's floodplain regulations. These regulations are intended to promote sustainable development by requiring that structures be protected from the 100-year flood. There are no perceived economic impacts on the business community that could impact city revenues.

Environmental: Environmental impacts are limited since the proposed flood mapping changes primarily affect existing developed areas of the city. There are no perceived significant environmental impacts based on considerations of transportation, climate, energy, greenhouse gas emissions, recycling, renewable and non-renewable resources.

Social: The flood study results provide better information for the community to assess flood hazards. There are no perceived impacts on the needs of diverse communities, e.g. different ethnicities and cultures, abilities, age, income, family demographics, or under-represented residents. There are no perceived impacts on intergovernmental relationships. The affected community has been engaged for input as summarized below.

BACKGROUND:

On April 17, 2007, City Council authorized the submittal of the South Boulder Creek (SBC) Flood Mapping Study results to the Federal Emergency Management Agency (FEMA), and the mapping study was submitted on Aug. 23, 2007. City staff received comments from FEMA on the initial submittal and addressed these comments in a re-submittal package dated Dec. 30, 2008 (see **Attachment A**). It is anticipated that FEMA will complete its review of the revised flood study results in early 2009. After FEMA completes its review of the mapping study, it will solicit public comment as part of its review process, issuing a notice through the Federal Register.

The SBC mapping study results are intended to replace the current regulatory mapping that is based on a 1986 United States Army Corps of Engineers (USACE) study. The recently submitted SBC study was completed with the support and cooperation of FEMA, Colorado Water Conservation Board (CWCB) and Boulder County.

The SBC mapping study will be used to regulate both existing and newly designated floodplain areas and to revise the local Flood Insurance Rate Map (FIRM). Staff began regulating to the SBC study's revised floodplain areas on Jan. 1, 2008. There are a few properties that have been added to the floodplain since then, based on the information submitted to FEMA on Dec. 30, 2008, and staff plans to begin regulating these additional properties on April 1, 2009. Staff will notify these property owners through direct mail and owners of properties with buildings previously designated to be in the 100-year floodplain will be sent a reminder letter.

Assuming the study results are accepted by FEMA, there will be 700 structures (with a total of approximately 1,200 dwelling units) in the 100-year floodplain (Zone AE). Currently, there are approximately 460 structures (with approximately 500 total dwelling units) in the 100-year floodplain. Structures affected by the existing regulatory mapping are also affected under the new study results. Therefore, approximately 240 additional structures (with approximately 700 total dwelling units) will be impacted.

The August 2007 study results indicated a total of approximately 760 affected structures so the absolute number of affected structures has decreased based on the December 2008 study results. However, approximately 120 structures (approximately 500 dwelling units) are newly affected by the December 2008 compared to the August 2007 results, whereas approximately 130 structures (approximately 130 dwelling units) shown to be affected by the August 2007 study results are no longer affected by the 100-year floodplain (Zone AE).

Owners of structures in the 100-year floodplain (Zone AE) are required to carry flood insurance if they hold a federally backed mortgage, and structures are subject to city and county flood regulations. Within the 100-year floodplain (Zone AE), a permit is required for any development or construction. Where construction is permitted, it must conform to flood protection standards that require, at a minimum, the lowest floor of any residential building to be at least two feet above the base flood elevation. Non-residential buildings must be elevated to the same flood protection elevation or may be flood-proofed such that below the flood protection elevation, the structure is water tight with walls substantially impermeable to the passage of water. Additional requirements apply to building crawl spaces, attendant utilities, and the need to adequately anchor structures against flotation, collapse or lateral movement. Any storage or processing of hazardous materials is prohibited below the flood protection elevation. The city of Boulder also prohibits the development of new automobile parking where flood depths exceed 18 inches. Significant additions and remodels (50 percent or greater) generally require that the entire structure be brought into conformance with applicable regulations.

During the remaining FEMA review period, city staff will continue to regulate to the study results for all annexation and development proposals. This approach is consistent with the Boulder Revised Code (BRC), Paragraph 9-3-2(d)(13):

“The city manager shall administer the requirements of this Section and shall Obtain, review, and reasonably utilize any base flood elevation and floodway data available from federal, state, and other sources, including data developed pursuant to Chapter 9-12, "Subdivisions," B.R.C. 1981, as criteria for requiring that all new development meet the requirements of this Section.”

In addition and pursuant to the city's participation in the National Flood Insurance Program (NFIP), the city will not remove any property or structures from the floodplain until FEMA completes its review. In essence, during the FEMA review period, the city will regulate to the more restrictive flood condition between the existing regulatory maps and the proposed study results/maps.

As set forth under NFIP regulations, buildings located in the 100-year floodplain as defined on the local Flood Insurance Rate Map (FIRM) are subject to the mandatory purchase of flood insurance, if the property is financed under a federally-backed mortgage. Most home mortgages fall under this category since most lenders are federally regulated. As a result of the new SBC floodplain mapping, many additional property owners will be subject to the NFIP mandatory purchase of flood insurance requirements. The notification letters will inform property owners about these flood insurance requirements, the FIRM map and the "grandfather provisions" that provide a mechanism whereby structures previously considered outside the South Boulder Creek floodplain and constructed without flood protection measures may be eligible for reduced insurance rates.

For those properties added to the floodplain, the requirement to purchase flood insurance won't be mandatory until the proposed revision of the FIRM is adopted by FEMA. Adoption of the revised FIRM is expected to occur within the next 12 months and will follow a 90-day appeal period for public review. This provides time for property owners to learn more about the mandatory requirement and to take advantage of coverage and premium options available before the purchase of flood insurance is required.

The South Boulder Creek Web site has been updated with the latest information and this is located at: www.southbouldercreek.com.

NEXT STEPS:

It is anticipated that FEMA will complete its review of the revised flood study results in early 2009. After FEMA completes its review of the mapping study, it will solicit public comment as part of its review process, issuing a notice through the Federal Register.

A risk assessment was completed in January 2008 in order to support subsequent flood mitigation planning. The risk assessment will be updated with the latest flood study results, and flood mitigation planning will begin as soon as practical after the flood study results have been accepted by FEMA, Boulder County, the city of Boulder and other agencies. It is anticipated that the focus of these efforts would be primarily to mitigate the impacts of flooding in the West Valley, where flood impacts were previously not identified and substantial urban development has occurred.

Currently, funding has been included in the city's CIP in 2008-2010 to complete the risk assessment and the flood mitigation planning effort, and \$3 million has been proposed in the city's 2011 budget to help fund flood mitigation construction improvements. (Specific improvements are yet to be determined by the flood mitigation planning mentioned above.) Also, an agreement with the Urban Drainage and Flood Control District has been secured and provides a total of \$100,000 of supplemental funding for flood mitigation planning.

The city is pursuing federal funding to help offset the cost of flood mitigation planning and flood mitigation project construction. Congress appropriated \$98,400 in fiscal year 2008 for use by the U.S. Army Corps of Engineers to initiate the General Investigation Study of this floodplain. The city requested an additional \$500,000 in the fiscal year 2009 budget, and U.S. Senator Wayne Allard secured \$250,000 for the project as part of the 2009 Senate Energy and Water

Development Appropriations Subcommittee Appropriations Bill. There is no funding mentioned in the President's budget for 2009, so hopefully there will be support in the U.S. House and Senate conference for this funding. It is important that flood mitigation planning efforts proceed concurrently with the U.S. 36 Corridor Improvements-Environmental Impact Statement.

For more information about the South Boulder Creek Flood Mapping Study, please contact Bob Harberg at (303) 441-3124 or at harbergb@bouldercolorado.gov.

ATTACHMENTS:

Attachment A: FEMA Re-Submittal Letter dated December 30, 2008



CITY OF BOULDER

Department of Public Works/Utilities Division
Planning and Project Management
PO Box 791
1739 Broadway
Boulder, CO 80306
(303) 441-3266
(303) 441-4271 FAX

December 30, 2008

Mr. Dave Jula
Michael Baker Jr., Inc.
355 Union Boulevard
Suite 200
Lakewood, CO 80228

Re: South Boulder Creek, Boulder, Colorado
Floodplain Mapping Study Submittal to Update the Boulder County Flood Insurance
Study and Flood Insurance Rate Map

Dear Mr. Jula:

On August 23, 2007, the City of Boulder submitted to you the results of the above referenced study and requested your approval of a Physical Map Revision to update the Boulder County Flood Insurance Study and associated Flood Insurance Rate Map. The study was completed with the support and cooperation of the Federal Emergency Management Agency (FEMA), Colorado Water Conservation Board (CWCBC) and Boulder County.

We received your comments on August 2007 submittal (see Attachment A) and have modified the hydraulic models, reports and mapping accordingly. We have also addressed comments raised during less formal communications with Baker staff in Alexandria. A summary of your comments and the city's response is presented as Attachment B. In addition, we incorporated information presented to us by the Flatirons Industrial Park as noted in Attachment B.

As before, we present modeling information concerning the University of Colorado South Campus under two scenarios 1) with berm and 2) without berm. Although the berm has not yet been certified, we understand that the State of Colorado plans to submit the berm for certification as noted in Attachment C - University of Colorado South Campus Berm Letter dated December 4, 2007.

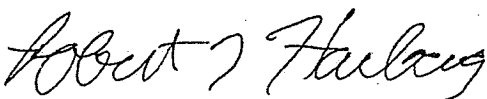
The detailed re-submittal is transmitted herewith as summarized in Attachment D - TSDN outline.

We trust you will find the information clear and comprehensive. However, should any questions arise that are not addressed by the information provided, please do not hesitate to contact me to ensure you are directed to the appropriate technical resource.

I may be contacted via e-mail at harbergb@boulder.colorado.gov, phone at 303-441-3124 or regular mail at the City of Boulder, P.O. Box 791, Boulder, CO 80306.

We appreciate your review of the previously transmitted documents and look forward to your comments and the eventual preparation of a physical map revision for South Boulder Creek that may update the Flood Insurance Study and associated Flood Insurance Rate Map.

Sincerely,
CITY OF BOULDER



Robert J. Harberg, P.E.
Utilities Planning and Project Management Coordinator

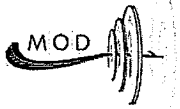
ATTACHMENT A: FEMA Comments dated November 2, 2007

ATTACHMENT B: City of Boulder Response to FEMA Comments

ATTACHMENT C: University of Colorado South Campus Berm Letter dated December 4, 2007

ATTACHMENT D: TSDN Outline

cc: with complete TSDN submittal via electronic external hard drive
Nancy Steinberger, FEMA Region 8 – No Hard Drive – Only Physical Map
Paul Hindman, UDFCD
Tom Browning, CWCB
Dave Webster, Boulder County
Mark Glidden, CH2MHill
Eric Fontenot, DHI
Alan Taylor, Alan Taylor Consulting
John Henz, HDR
Ned Williams, City of Boulder



Mapping On Demand
355 Union Blvd, Suite 200
Lakewood, CO 80228
(303) 514.1100 tel.
(303) 514.1120 fax

November 2, 2007

Mr. Robert J. Harberg
Utilities Planning and Project Management Coordinator
PO Box 791
1739 Broadway
Boulder, Colorado 80306

Dear Mr. Harberg:

This letter is in response to your letter dated September 5, 2007, requesting a review of the flood mapping study for South Boulder Creek. Michael Baker Jr., Inc., FEMA's National Service Provider (NSP), has completed its review of this submission. The purpose of this letter is to summarize our review comments and provide corresponding documentation detailing our review.

The scope of this review included Activity 2C – Independent QA/QC Review of New Hydraulic Analyses as detailed in the Colorado Water Conservation Board Mapping Activity Statement No. 6 – Digital Flood Insurance Rate Map Production and Development of Updated Flood Data. The results of our review found several items that must be addressed prior to FEMA's incorporation of the South Boulder Creek analyses in a Physical Map Revision. Our review comments are summarized in the attachment.

Feel free to contact myself in regards to any questions or comments you have on this review.

Sincerely,

David R. Julia
Regional Management Center VIII Lead

Cc: Nancy Steinberger, FEMA Region VIII
Dan Carlson, FEMA Region VIII
David Lloyd, Urban Drainage and Flood Control District
Dawn Gladwell, Colorado Water Conservation Board
Alan Taylor, Alan Taylor Consulting
Mark Glidden, CH2MHill

South Boulder Creek, Boulder, Colorado
Hydraulic Analysis and Floodplain Mapping Review Interim Summary
Michael Baker Jr. Inc.
November 2007

We have conducted an independent QA/QC review of hydraulic analysis for South Boulder Creek, Boulder County, Colorado. The hydraulic analysis used a MIKE FLOOD model, conducted by DHI. The primary purpose of this review is to ensure that the data and modeling are consistent with FEMA standards and standard engineering practice and sufficient to revise the Flood Insurance Rate Maps (FIRMs) for South Boulder Creek. The review focuses on the modeling of the 1% annual chance (100-year) flood.

The technical review efforts concentrate on the following subjects:

- Use of accepted models and duplicate the modeling results
- Starting water surface elevation/initial conditions
- Flood discharges
- Cross section geometry
- Roughness coefficient and expansion/contraction coefficients
- Bridge and culverts modeling
- Regulated floodway computation methods
- Tie-in to non-revised profiles

We also reviewed the modeling levee/berm in the vicinity of University of Colorado South Campus.

DHI provided all necessary support to facilitate the review, including a meeting with the review team in Baker's Alexandria office on September 10, 2007. Many issues were discussed and consequently resolved during the review process. The discussions which have been documented by e-mail and telephone records are excluded from this interim review summary.

The hydraulic review is incomplete at this time because additional data is required. This interim summary focuses on major findings and additional data needed to continue the review.

Use of Accepted Model and Results Duplication

The submitted hydraulic model was prepared by using MIKE FLOOD Version 2005; DHI provided a copy of MIKE FLOOD Version 2007 for review use. Both versions are accepted by FEMA. MIKE FLOOD consists of two modules: MIKE 11 and MIKE 21, which are conjunctively used in this study.

A duplicate run for the 100-year flood, with the South Campus berm condition modeled, was completed successfully. Differences in the water surface elevations between the submitted and the duplicated models are less than 0.16 ft (0.05 meters) and are

considered negligible. An error was found for the 100-year “without berm” condition model, details are described in a separate section of this summary. Consequently we did not duplicate the “without berm” condition.

Starting Water Surface Elevation/Initial Conditions

The channel minimum flow depth of 0.05 meter, approximately 5 cfs, was assumed for the initial water depth. This is an acceptable assumption.

Flood Discharge/Use of Truncated Inflow Hydrograph

The inflow at the upper modeling boundary of South Boulder Creek, as given in MIKE11 at Branch 2 Chainage 173.86, is shown in Figure 1. The inflow hydrograph lasted 54 hrs from 05/31/1998 6:00 PM through 06/03/1998 12:00 AM. The simulation period of the MIKE FLOOD model begins at 06/01/1998 8:00 PM and ends at 06/02/1998 5:00 AM, shown as truncated by the pink lines in Figure 1. The peak of this inflow hydrograph is captured but the inflow volume is less than the volume of the entire hydrograph.

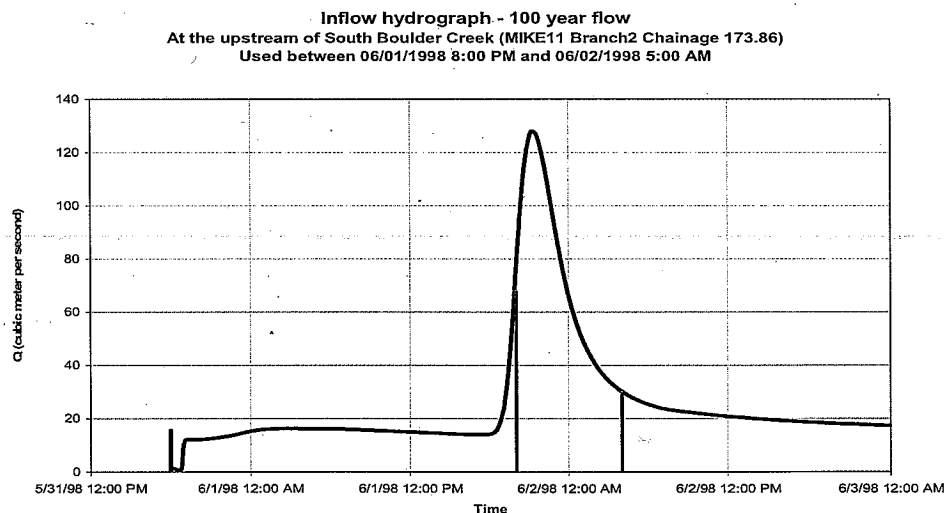


Figure 1 – Inflow hydrograph at Eldorado Springs

Use of the truncated hydrograph was discussed with Eric Fontenot of DHI. He explained that the un-routed portion of the hydrograph, representing in-channel flows, does not have a significant impact on the overbank flooding and does not represent the volume that could be stored in the floodplain. As such, the un-routed portion of the rising limb of the hydrograph has little impact on the flood hazards.

We evaluated the travel time of flood waves to verify the methodology. The travel time for the 100-year hydrograph from the upper modeling boundary to the confluence of South Boulder Creek with Boulder Creek, as simulated by the MIKE FLOOD model, is approximately four hours, from 9:15 PM to 1:30 AM of the next day. The nine-hour

simulation period of the MIKE FLOOD model is much longer than this travel time. An independently developed HEC-RAS model confirmed the travel time.

The evaluation concluded that the duration of the truncated inflow hydrograph is long enough for the stream to reach the maximum water surface elevation within the channel and in the overbanks.

Roughness Coefficient and Expansion/Contraction Coefficients

The model used the roughness coefficient (Manning's n) value of 0.06 for non-urban areas and 0.08 for urban areas. Typically, n value of 0.08 corresponds to an undeveloped floodplain covered by dense weeds.

The study team reported that they were unable to obtain any flow records or high water marks from historical flooding events. The hydraulic model was checked by "ground-truthing" based on photos of flooding area taken during a 1969 flood, which had a peak flow rate of 1690 cfs at Eldorado Springs. It was a relatively small event compared to the 100-year peak flow of 4520 cfs (Table 1, page 14) at the same location. No flood volume data was reported for the 1969 flood. The locations shown on the 1969 photos used in the "ground truthing" are at South Boulder Road and Baseline Road; both are located upstream from the urbanized area where rapid urbanization has occurred since.

Issues were discussed with DHI as well as with Mr. Robert Harberg, City of Boulder. Both believed that these values, although not calibrated nor verified, are the best estimates based on the team's engineering judgment.

Given that these roughness coefficient values had been reviewed and decided as being reasonable (2005 QA/QC review); we did not pursue further review and evaluation.

The MIKE FLOOD model has built-in values of 0.3 and 0.5, respectively, for bridge contraction and expansion coefficients. These coefficients are typical values; we do not have reason to believe that the default values for culverts are non reasonable although the built-in values for culvert are neither visible and nor changeable for user.

Cross-section Geometry

The cross-section geometries seemed reasonable and acceptable with the exception of the "without berm" condition as discussed below.

Bridge and Culvert Modeling

There are 12 bridges, 60 culverts, and 5 control structures modeled; no problems were found in the bridge and culvert modeling methodologies.

Please note that no detailed descriptions or plans for these structures were provided. Therefore, we were unable to verify locations, types and dimensions for these structures.

Tie-in to Upstream and Downstream Effective Flood Profiles

The model used the effective Base Flood Elevation (BFE) of 5175 ft (1577.34 meter) as the downstream boundary condition; the simulated 100-year flood profile tied to the effective elevation of Boulder Creek at the downstream. The study covered the entire South Boulder Creek floodplain; therefore, there is no tie-in issue at the upstream extent of the model.

University of Colorado South Campus Berm Modeling

The University of Colorado South Campus is surrounded by a berm owned by the State of Colorado. Certification documents were not provided to demonstrate that the berm meets all criteria specified in NFIP Regulation 44 CFR Part 65.10. Therefore, the floodplain must be modeled and mapped based on the "without berm" condition in the hydraulic model. The berm was correctly reflected in geometry files of both MIKE 11 and MIKE 21 for the "with berm" condition; however, it was only removed in the MIKE 21 module and still exists in MIKE 11 geometry for the "without berm" condition. The "without berm" condition model and affected floodplain mapping must be revised and resubmitted for further review.

The "without berm" condition model was described briefly in the hydraulic report. It is a key issue for the South Boulder Creek floodplain modeling and mapping; the report should be revised to explain in greater detail how the "without berm" condition is modeled. Adding a table of BFE comparison between "with berm" and "without berm" conditions at key locations would clearly show the impact of the berm.

Regardless of the certification status of the berm, the "without berm" condition must be accurately represented. This condition would be used to designate the flood hazard if the berm is not certified. Additionally, if the berm is certified, the "without berm" results are used to map the area inundated if the levee were to fail (represented by a shaded Zone X with levee note on the FIRM).

Below we summarized information necessary to complete the "without berm" condition review:

- A revised MIKE FLOOD model with correct geometry files;
- Revised floodplain work maps; and
- A table showing BFE comparison between with berm and without berm conditions (optional).

Regulatory Floodway Computation

The floodway model was not provided in the September 5, 2007 submittal; therefore, the review was limited to the floodway modeling method described in Technical Support Date Notebook (TSDN) Section 3.8, Conveyance Zone, and Appendix G of TSDN 2.3, Hydraulic Analysis.

Currently, FEMA does not have explicit guidelines and specifications on floodway methodologies utilizing two-dimensional modeling techniques. The conjunctive use of MIKE 11 and MIKE 21 modules is a unique feature being applied to the South Boulder Creek floodway determination; the in-depth review has to be conducted on the methodology used to define the floodway. Detailed information on key issues, such as how the conveyance reduction was computed for the given encroachments, should be added to the report.

Table 5 – Cross Section (page 47 of the TSDN) presents BFEs for both Regulated Floodplain and Floodway. It shows an excessive surcharge of 3.3.ft at cross section H and a negative surcharge of -0.26 ft at cross section AW. These surcharges do not satisfy the NFIP regulated surcharge limitation of 0.0 to 1.0 ft.

For a NFIP floodway analysis, the same hydrograph should be used in both floodplain and floodway hydraulic models. We were unable to verify this requirement without the floodway model. The report did not specify whether the same hydrograph was used for both models. It appears that some flows were removed for the floodway model (page G-3, Appendix G of the TSDN). A table with inflow hydrographs and split flows at key locations for both models should be provided for the clarification.

Below we summarized information necessary to complete the floodway model review:

- Revised Section 3.8 and/or Appendix G to provide more details on the floodway methodology, especially conveyance reduction and encroachment methodology;
- Revised floodway model that satisfies the NFIP surcharge criteria for all cross sections; and
- Tabulated flow rate used in floodplain and floodway model at key locations.

Flood Insurance Study (FIS) Products

In general, the submitted support tables and flood profiles do not meet the specifications outlined in FEMA's Guidelines and Specifications as required in the Colorado Water Conservation Board, Mapping Activity Statement No. 6 – Digital Flood Insurance Rate Map Production and Development of Updated Flood Data.

FEMA's Summary of Discharge Table includes names of flooding sources, drainage areas, and peak discharges for 10-, 50-, 100-, and 500-year flood event. We recommend adding drainage areas to the submitted discharge table to comply with the standard FIS format. Because of complexity of the MIKE FLOOD model, identify these location with their x, y coordinates would be helpful for future users. A template of the standard FIS Summary of Discharges Table is available upon request.

The submitted Floodway Data Table is not in the standard FIS format although all data needed to create the standard FIS Floodway Data Table are included. A template of the standard FIS Floodway Data Table is available upon request.

A note was posted on each page of the flood profiles to inform users that the flood profiles are generated from two-dimensional modeling which provide greater details. It further recommends using BFEs from the MIKE FLOOD BFE contour map or inundation raster GIS data to determine accurate BFEs.

Flood profiles in FIS have been established as the most accurate information for BFEs. Although flood profiles on flood plains may be different from channel flood files, the flood elevation shown in the flood profiles still accurately reflect the channel water surface elevation of South Boulder Creek.

One of the major advantages of two-dimensional model is its capability to accurately identify flow paths and compute water surface elevations along these flow paths. Flood profiles are no longer limited to the main channel only. Instead, user can generate flood profiles along multiple flow paths if necessary. For this study, flood profiles may be generated for additional flow paths, such as in the West Valley, to provide user easy access and accurate information.

Summary

The following must be submitted to finalize our review of the South Boulder Creek study:

- A revised model and floodplain mapping, modified to correctly reflect the "without berm" condition.
- The floodway model for South Boulder Creek with surcharges between 0.0 and 1.0 feet, including any necessary revisions to floodplain mapping products.
- Documentation of floodway methodology, to include but not limited to conveyance reduction and encroachment methodology.
- Summary of Discharges Table, Floodway Data Table and Flood Profiles need to be reformatted to the standard FIS formats.

	Floodplain Model - FEMA Review Comments	Notes	Action Item
	<p>The flow in South Boulder Creek (BRANCH2 in MIKE11) passing the bridge at Highway 36 is 75.77 m³/s; however, just at the downstream cross section, the flow is 125.2 m³/s. The flow in Dry Creek Ditch #2 passing the culvert underneath Highway 36 is 4.2 m³/s. Please explain why the flow is enlarged from 75.77 m³/s to 125.2 m³/s</p>	<p>In reviewing the increase in discharge occurring from chainage 9401.76, the location of the bridge at HWY36 and chainage 9441.42, the next downstream link, it appears that the backwater that accumulates behind the bridge causes a lot of lateral inflow from MIKE 21 to MIKE 11. This lateral inflow applied to the next downstream H-point in the MIKE 11 model, this transferred volume then shows up as an increased discharge at the next downstream Q-point. In effect the lateral link, as defined in MIKE FLOOD, is transferring water across the road embankment. The water transferred by the lateral link is by-passing the bridge opening; in effect water is being transferred from the floodplain upstream of the HWY36 road embankment to the main channel downstream of the bridge.</p>	<p>In order to prevent this phenomenon from occurring in the model, the lateral link will be split into two separate lateral links, one that allows transfer of water between the 1D and 2D models upstream of the HWY36 bridge, and a second one that represents the channel floodplain interaction downstream of the bridge. In this manner, the bridge and road embankment will be preserved as a hydraulic control point.</p>
1	<p>Flow rate is increased from 84.9 m³/s at the bridge (Chainage 14171.39 at BRANCH2) to 94.8 m³/s at its downstream cross section, and then to 153.7 m³/s at Chainage 15448.10, while the first cross section at DryCreekDitchNo2_North has zero inflow and it looks to me there is no major inflow in the floodplain.</p>	<p>Examination of the increase in flows occurring from Chainage 14171.39 to Chainage 14206.22 appears to be caused by the lateral link defined in MIKE FLOOD transferring water across the railroad embankment as previously described. This transfer of water across a hydraulic control point can be corrected by redefining the lateral link</p>	<p>In order to prevent this phenomenon from occurring in the model, the lateral link will be split into two separate lateral links, one that allows transfer of water between the 1D and 2D models upstream of the hydraulic control, and a second one that represents the channel floodplain interaction downstream of the hydraulic control.</p>
2	<p>Flows enter Baseline Reservoir never return to the creek again and the reservoir elevation increases 2-3 ft during the simulation. Water surface in the reservoir is approximately 5,307.2 ft. The top of bank at Cross Section AE is approximately 5316.2 ft. The reservoir played significant role in flood reduction. How was the initial elevation of the reservoir determined? Is there any operating plan to maintain such elevation?</p>	<p>The pool elevation of the reservoir was taken from the detailed topographic survey and verified as appropriate through review of reservoir operations. The project team is gathering the reservoir operation documentation to verify that the storage volume credited to the reservoir has been appropriately represented in the hydraulic model. However, it is also important to note that the inflows to the reservoir are hydraulically controlled by upstream overflows across Cherryvale Road and South Boulder Road. The model is constructed with the assumption that these control elevations are high enough to not be impacted by any storage in the reservoir. An initial review suggests that changes in the starting water surface of the reservoir will not change this assumption. We are conducting research to confirm the potential impact of reservoir operations. The reservoir operating documents will be forwarded under separate cover.</p>	<p>No changes made in MIKE FLOOD model. Effects of Baseline Reservoir on the flooding are accounted for and explained in a TM prepared by Alan Taylor.</p>
3	<p>How did you model the UC Berm in MIKE FLOOD? The hydraulic report said, "the without berm condition was created by removing the berm and interpolating elevations from the south toe to the north toe". Did you model the Berm in MIKE11 by using the top of the Berm as the bank station of one cross section? Or did you model the Berm in MIKE21 by raising the grid elevation to the top of the Berm? If you modeled the Berm in MIKE11 using cross sections, please let us know the river branches and the chainage ranges that contain the Berm. If you use other method to model the Berm, please explain your method how you modeled the Berm in MIKE FLOOD.</p>	<p>The without berm scenario in MIKE FLOOD removed the berm from the M21 bathymetry, but failed to remove the berm from being represented as part of the Mike 11 cross section geometry. This results in the berm still being modeled as a 1D feature and providing flood protection. If the levee fails certification, then the without berm scenario will have to be rerun.</p>	<p>In the model set-up for the without CU Berm, the bank markers in the 1D cross sections from chainage 2013 through 3301 were edited to remove the berm as a feature. The berm was also removed from the M21 bathymetry and initial conditions! dfe2 files.</p>
4	<p>Flatirons Industrial Park has raised several issues and challenges to the base run. These issues include, the representation of the RR embankment, local elevations within the industrial park, removal of berm/ring levee and the internal drainage facilities.</p>	<p>It is the intention of the City to address these challenges as part of the FIS resubmittal.</p>	<p>Incorporate changes to the RR embankment, internal drainage facilities and the local elevation data within the Flatirons Industrial Park.</p>
5	<p>Truncated hydrograph; starting the simulation after a portion of the rising limb has passed may underestimate the volumetric impacts to flooding.</p>	<p>The simulation start time was chosen with respect to the bank full capacity of South Boulder Creek. It is believed that starting the simulation on the rising limb of the inflow hydrograph has minimal impact on the flood depths and extent of inundation. Due to the highly dynamic nature of the South Boulder Creek floodplain, it is difficult to say with certainty what the impact of not routing some portion of the inflow hydrograph would have on flooding.</p>	<p>The model start time was changed from 8PM to 6PM to account for the whole of the rising limb of the hydrograph. This ensures that all impacts due to flood volume are accounted for in the model simulation.</p>

				The confluence area was modeled in the 1D/2D coupled model, with an open boundary at the northern extent and a line of sinks applied along 61st Street to remove water from the system. This approach alleviates the boundary effects and would leave the area of mapping interest under normal hydraulic conditions.
7	Confluence area - downstream of Valmont Road		This area is a large mix of SBC and Boulder Creek floodplains, with no real clear cut method to model this area. In the existing effort, we have created a separate 1D confluence model. The constant trans-basin inflow from Bear Canyon Creek is conservative and results in an overestimate of flooding risk in the West Valley. A more representative dynamic hydrograph will be applied as an inflow boundary condition.	The dynamic hydrographs prepared by HDR and Alan Taylor will be applied at the specified inflow points.
8	Bear Canyon Creek inflows			Alan Taylor, in conjunction with the City of Boulder, has developed the loading points for the C2 basin. The inflow boundary conditions will be changed to reflect this more resolved depiction of runoff loading.
9	C2 Loadings			
10	FEMA Map presentation issues			
11	Gapier Road Survey		The City of Boulder has detailed survey data around Gapier Road.	The detailed survey data from Gapier Road will be incorporated into the MIKE 21 model bathymetry.
12	NE Arapahoe Road Survey		A development project in NE Arapahoe is underway, and site grading is underway. The City has survey data of the current conditions of the site, and will provide this data to DHL.	The detailed survey data from NE Arapahoe Road will be incorporated into the MIKE 21 model bathymetry.

Floodway Model - FEMA Review Comments		Notes	Action Item
1	Lateral links through hydraulic control points	This issue will need to be addressed in both the base runs and encroached runs. Operation of Baseline Reservoir is in question for base runs. If changed, then these changes will also need to be incorporated into encroached runs	Update encroached simulations with updated lateral link definitions at hydraulic control points.
2	Baseline Reservoir		Update Baseline Reservoir implementation in encroached runs.
3	Couple upstream 1D and 2D simulations	Currently, the upstream portion of the model represented as a 1D channel is simulated separately from the floodplain. These two runs should be coupled together as a contiguous run.	Couple 1D and floodplain encroached models together
4	Flatirons Industrial Park has raised several issues and challenges to the base run. These issues include, the representation of the RR embankment, local elevations within the industrial park, and the internal drainage facilities.	Changes made in the industrial park as part of the base run will also need to be included in the encroached simulations.	Incorporate changes to the RR embankment, internal drainage facilities and the local elevation data within the Flatirons Industrial Park for the encroached simulation.

Floodway Model - Flatirons Industrial Park Comments		Notes	Action
			Height of RR embankment, as applied in model was applied from the survey data collected by the Flatirons company, LRCWE and Sayre. The height of the subgrade was determined by applying the following equation: Subgrade = Top of Rail - rail - ballast, where the rail was assumed to have a 6" height, and the ballast a 2' height.
1	Representation of the RR embankment	FEMA guidelines dictate/control how the RR embankment is represented in the model. FEMA requires the use of the "subgrade" elevation, and does not give credit for height of ballast.	TXT survey files were converted to XYZ files, and imported into the M21 bathymetry editor. Using a search radius of 1, survey data was converted to local elevations and imported into the model elevation file. TXT files used were: FIP-B3.txt, FIP-SP6.txt, FIP-C5.txt, FIP-SPC4.txt, FIP-SPC7.txt, FIP-SPC9.txt, FIP-SPC8.txt. These files represent all of the survey elevation data for buildings received from LRCWE.
2	Local Elevations within Flatirons Industrial Park	Flatirons company, through LRCWE, provided detailed survey information of ground elevations at buildings and at 4 meters away from key buildings of interest. Survey data was provided in txt format.	The following internal drainage features were included: Flatirons West drainage channel and a Flatirons East drainage channel. The key interior drainage facilities were incorporated from the FEP-SPC2.txt and KeyDrainageFacilities.shp files provided by LRCWE.
3	Internal Drainage System	Flatirons company requested that the internal storm water drainage system be represented in the floodplain model. Digitized alignment of internal drainage system from survey points provided by LRCWE. These features were digitized into 1D model elements in MIKE FLOOD. From sections for internal drainage channels were cut from the 1m DEM created from 1' contour data.	Channel alignment and cross-sections were taken from FIP-SPC3.txt and InterceptorChannelPoints.shp files provided by LRCWE.
4	Interceptor Channel	The interceptor channel was brought from the 2D model into the 1D domain to more accurately describe the channels conveyance capacity.	The toe of the ring levee on both the channel side and Flatirons park side were digitized from the elevation model based on the 1' contour elevation prepared by Merrick. Deleted the levee and interpolated a new ground surface elevation from internal to external toe. The levee was also removed from the MIKE 11 model by moving the bank markers in the cross section file to match the newly interpolated ground surface elevation.
5	Ring Levee	Per FEMA guidelines the ring levee surrounding the Flatirons Industrial Park had to be removed from the model because it lacks certification.	



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December 4, 2007

Mr. David R. Jula
Regional Management Center VIII Lead
Mapping on Demand
355 Union Blvd., Suite 200
Lakewood, CO 80228

Re: South Boulder Creek, Boulder, Colorado

Dear Mr. Jula:

We have been provided a copy of your letter of November 2, 2007, and the Hydraulic Analysis and Floodplain Mapping Review Interim Summary prepared by Michael Baker Jr. Inc. dated November 2007. With respect to the portions of that Summary referring to the University of Colorado South Campus Berm Modeling it is stated that certification documents were not provided to demonstrate that the berm meets all criteria specified in NFIP Regulation 44 CFR Part 65.10. I am writing this letter to advise you that the University of Colorado, the owner of the berm, has previously and intends again to submit appropriate certification documents.

On August 26, 1999, this writer, in response to a request from FEMA (Mr. John Liou of FEMA Region VIII) apparently under 44 C.F.R. §65.10(a), submitted to FEMA a report dated August 24, 1999 and 11 appendices containing technical information to confirm that the berm or levee met the criteria contained in 44 C.F.R. §65.10(b) subparagraphs 1 through 6. The levee was constructed sometime during or before 1980 and was then apparently, and to date continues to be, recognized on the existing FIRM.

The technical information submitted divided the levee into three discreet sections: (1) the upstream 4,570 lineal feet which the undersigned concluded met the requirements set forth in 44 C.F.R. §65.10; (2) the middle reach of about 1,700 feet which it was believed was not required to meet the requirements of 44 C.F.R. §65.10 because the base flood did not abut the levee; and (3) the downstream reach of about 1,250 feet which the undersigned concluded did not meet the criteria for recognition. By letter dated June 15, 2000, Matthew B. Miller, P.E., Chief Hazards Study Branch for FEMA, following review of the technical data submitted, concluded that the upstream reach of the levee meets all of the requirements of 44 C.F.R. §65.10. He also stated that FEMA agreed that the middle reach of the levee does not need to meet the requirements of 44 C.F.R. §65.10. Because the downstream reach of the levee did not meet the requirements of 65.10, Mr. Miller requested that we submit existing conditions topography and hydrologic and hydraulic analyses before any revision to the FIRM would be made. He requested that this be submitted within 90 days or that we request an extension of time to submit the information. On September 6, 2000, we did request an extension of time to permit the floodplain study to be completed because of the then ongoing floodplain study which has now resulted in the current September 2007 submittal by the City of Boulder.

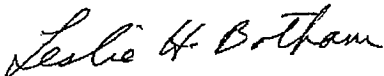
Mr. David R. Julia
December 4, 2007
Page 2

In light of the recent submittal by the City of Boulder, the University of Colorado intends to review and update as necessary the materials we submitted in 1999 to facilitate recognition on the FIRM of the upstream reach of the levee as a flood mitigation device. We are hopeful that this can be accomplished within the next several weeks. In the meantime, if you desire copies of any of the originally submitted data or communications, please let me know and I can provide that to you.

If you have any questions or request, please feel free to contact me by telephone.

Very truly yours,

LEONARD RICE CONSULTING WATER ENGINEERS, INC.



Leslie H. Botham, P.E.
Principal

cc: Nancy Steinberger, FEMA Region VIII
Dan Carlson, FEMA Region VIII
David Lloyd, Urban Drainage and Flood Control District
Dawn Gladwell, Colorado Water Conservation Board
Alan Taylor, Alan Taylor Consulting
Robert J. Harberg, City of Boulder
Mark Glidden, CH2MHill
David M. Packard, Packard and Dierking, LLC
Christine M. Arguello, University of Colorado



1.0 South Boulder Creek Floodplain Mapping

TSDN

1.0 General Documentation

1.0 Fly Sheet – Table of Contents

1.1 Contact Reports – email communication with FEMA/Baker

1.2 Meeting Minutes & Reports – weekly call summaries and progress meeting notes

1.3 General Correspondence

1.3.1 Correspondence with & from FEMA – letters from FEMA, UDFCD, Baker and USACE based on previous review

2.0 Engineering Analysis

2.1 Climatologic Analysis

2.1.1 Basin Climatology

- Colorado Climate Center: Colorado Extreme Precipitation event spreadsheet
- List of flooding dates for Boulder County prepared by HDR
- Key Flood events (1938 & 1969) – Data Folders of observations gathered from U.S. Bureau of Reclamation Flood Hydrology Section Storm Files. Data includes precipitation, meteorological observations and newspaper accounts.

2.1.2 NOAA Atlas II Update

- Precipitation Database developed for Boulder County precipitation gages including: Boulder, Boulder 2, Hawthorne, Gross Reservoir, Allenspark 2NNW, Longmont 2ESE, and Longmont 6 NNW.
- Depth Duration Frequency (DDF) calculation spreadsheets.
- DDF Calculation Reference Documents.

2.1.3 Basin Calibration

- July 8, 1998: UDFCD FDN Site precipitation for Gage Numbers 4010-4070 and 4530. Radar reflectivity observations from NWS WSR-88D- Watkins, Colorado. Upper-air observations for Denver, Colorado.
- August 4, 1999: UDFCD FDN Site precipitation for Gage Numbers 4010-4060, 4090, 4100, 4110, 4730 and 4360. Radar reflectivity observations from NWS WSR-88D- Watkins, Colorado. Upper-air observations for Denver, Colorado.
- Boulder, Gross Reservoir, and Coal Creek Canyon NOAA – Cooperative Stations: Daily Precipitation (liquid equivalent), daily snowfall (inches) and daily snowfall depth (inches), daily maximum temperature and daily minimum temperature.
- USDA - National Resource Conservation Service – SNOw TELemetry (SNOTEL) data from July 1, 1997 through August 31,

1999: Lake Eldora station including daily observations of liquid equivalent precipitation, surface snow water equivalent, daily maximum temperature, daily minimum temperature and daily mean temperatures (average of hourly temperature observations).

- 1938 Event Data: NOAA-Cooperative Data for the period of June 1, 1937 through August 31, 1938 for the Silver Lake, Hawthorne and Boulder stations. Data includes daily precipitation, daily snowfall, and daily snow depth for all three stations and daily maximum and minimum temperatures for Boulder.
- 1969 Event Data: NOAA-Cooperative Data for the period of January 1, 1968 through May 31, 1969 for the Caribou Ranch, Squaw Mountain, Hawthorne and Boulder stations. Data includes daily precipitation, daily snowfall, and daily snow depth for all four stations and daily maximum and minimum temperatures for Boulder and daily maximum and minimum temperatures for the Boulder and Caribou Ranch stations.

2.1.4 Scientifically Defensible Design Storm (SDDS) Development

2.1.4.1 Derivation of South Boulder Creek basin-specific updated DDF values for 6, 24 and 72-hour values.

- Spreadsheets of DDF calculations for determining values.

2.1.4.2 Thunderstorm (6-hour) SDDS

- Still frame images of storm total precipitation (STP) footprints for storms used in depth/area computations.
- GIS (gridded raster) data for each storm STP footprint.
- Spreadsheet data including results of radar-storm depth-temporal analyses.
- Spreadsheet data including results of GIS-derived storm area analyses.
- GIS (gridded raster) footprint for the 2, 5, 10, 25, 50, 100, 200 and 500-year storm total footprints for the SDDS.

2.1.4.3 General Storm (24/72-hour) SDDS

- Spreadsheet data containing the temporal distribution of the 2, 5, 10, 25, 50, 100, 200 and 500-year events.
- Spreadsheet data for past general storm events in Boulder County including numerous precipitation reports and upper-air data to support rain/snow/elevation delineations.
- GIS (gridded raster) data for the 2, 5, 10, 25, 50, 100, 200 and 500-year storm total footprints for the SDDS.
- Precipitation data for the March 17-20, 2003 storm for South Boulder Creek (and adjacent area) stations.

2.2 Hydrologic Analysis

2.2.1 Summary Report of Hydrologic Analysis

Task 3 TM and all appendices

2.2.2 Paleoflood Analysis – See Appendix F in 2.2.1

2.2.3 Computer Models, Calculations and Execution

Statistical Analyses – See Appendix E in 2.2.1

HEC-FFA input and output

Regression Equations computations

MIKE FLOOD RR Modeling Files

Input Files for calibration, validation, general and
thunderstorm events

Boundary Condition Files for calibration, validation,
general and thunderstorm events

Output Files for calibration, validation, general and
thunderstorm events

Sensitivity Analysis

2.2.4 Summary Report for Independent QA-QC

Letter from Baker saying hydrology preliminary accepted but
would be better if numbers were higher

2.3 Hydraulic Analysis

2.3.1 Summary Report of Hydraulic Analysis

Task 4 TM and all appendices

2.3.2 Cross Section Information

2.3.3 Key to Cross Section Labeling

To be created once cross-sections are identified and will include
cross section name, letters for FIS report and stationing

2.3.4 Cross Section Plots

Plots in Excel format from identified selected cross-sections

2.3.5 Computer Models, Calculations and Execution

2.3.5.1 Input files for 1969, sensitivity analysis

Boundary condition files for 1969, sensitivity analysis

Output files for 1969, sensitivity analysis

2.3.5.2 Computer models for production runs

Input files for production runs

Boundary condition files for production runs

Output files for production runs

2.3.5.3 Transposed Events

Big Thompson

Fort Collins

3.0 Draft FIS Report

3.1 FIS Report Narrative (Executive summary describing revisions)

3.2 Summary of Discharges Table

Recreation of the peak discharge and volume table from Task 4 TM

3.3 Floodway Data Table

Yet to be created but to include cross section data for BFE and floodway

3.4 Flood Profiles

- Presentation of mainstem flood profiles based on MIKE 11
- Presentation of West Valley flood profiles based on MIKE 21
- 3.5 Certification of Compliance for Work
- 3.6 Other Relevant Data
 - 3.6.1 Summary Report for Independent QA-QC
 - 3.6.2 Summaries of Public Meetings Taken From the Web Site
- 4.0 Mapping Information
 - 4.1 Topographic Mapping
 - 4.1.1 Photogrammetric Data
 - Submit raw data from Merrick
 - 4.1.2 Topography and Planimetric Files
 - Collection of GIS files that contain topography and planimetric data
 - 4.1.3 Ground Survey Data
 - Submit structural survey data and sketches from Merrick
 - 4.1.4 Aerial Photos
 - Submit high resolution aerial photos
 - 4.2 Physical Floodplain Map
 - 4.3 USGS Digital Orthophoto Quadrangles – Higher Resolution Data
 - resides in 4.1.4
 - 4.4 USGS Topographic Quadrangle Maps
 - 4.5 DFIRM Database Data (Basic)
 - 4.5.1 DFIRM databases are not part of our scope of work
 - 4.5.2 Floodplain Mapping
 - 4.6 Flood Inundation Maps
 - 4.7 Base Map Data
- 5.0 Miscellaneous Reference Materials Index
 - 5.1 Effective FIS for City and County – Boulder County, Colorado and Incorporated Areas October 4, 2002
 - 5.2 Effective FIRM for City and County – Reference Panels 08013C0550 F, 08013C0535 F June 2, 1995, 08013C0555 G October 4, 2002, 08013C0415 F October 4, 2002
 - 5.3 Site Photographs
 - Submit site photographs from Merrick and HDR.